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MAIZE VARIETAL RESPONSE TO INTEGRATED NUTRIENT MANAGEMENT OF NPK AND CHICKEN MANURE

Abstract

Two field experiments were conducted for two years at the Multipurpose crop nursery, University of Education, Winneba, Mampong-Ashanti from May to August, 2015 and 2016 respectively to evaluate ~~maize~~ varietal (Omankwa and Obatanpa) response to integrated nutrient management of NPK and Chicken manure (3 t ha^{-1} CM, ½ CM + ½ NPK and ¾ CM + ¼ NPK). The experimental design used was a 2 x 5 factorial arranged in randomized complete block design with three replicates. The result showed that there was a significant difference between Obatanpa and Omankwa and fertilizer type in total grain yield in both cropping seasons. Obatanpa grown on 65:38:38 kg ha^{-1} NPK produced thicker cob diameter, higher dry matter accumulation, taller plants at 77 days after planting, and total grain yield in both cropping seasons. Obatanpa grown under 3 t ha^{-1} CM produced the longest cob length and heaviest 100 seed weight during the 2016 cropping season. Obatanpa grown under ¾ CM + ¼ NPK produced thicker cob diameter during the 2016 cropping season. In conclusion (i) Obatanpa which was outstanding in maize grain yield, cob diameter and length should be grown by farmers. (ii) Farmers who prefer mineral fertilizers for increased grain yield and thicker cob diameter of maize should apply 65:38:38 kg ha^{-1} NPK. (iii) Farmers who practice organic agriculture in transitional agro-ecological zone of Ghana should apply 3 t ha^{-1} Chicken manure and ¾ CM + ¼ NPK to enhance maize grain weight, cob length and cob diameter respectively.

Key words: Obatanpa, Omankwa, Chicken manure, mineral fertilizer, cob diameter, grain yield

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1. **Introduction**

Maize (*Zea mays* L) is one of the major cereal crops grown in the humid tropics and sub-Saharan Africa. It is a versatile crop and ranks third following wheat and rice in world production [1]. Maize crop is a key source of food and livelihood for millions of people in many countries of the world. It is produced extensively in Ghana, where it is consumed roasted and boiled. It is also processed and consumed as *banku*, *apkle*, and porridge. In advanced countries, it is an important source of many industrial products such as corn sugar, corn oil, corn flour, starch, syrup, brewer's grit and alcohol [2]. Maize is a major component of livestock feed and it is palatable to poultry, cattle and pigs and supplies them energy [3]. Increase in demand of the commodity resulted in expanding production in many areas in Ghana. The soils in the country are generally low in fertility due to continuous crop cultivation as a result of increase in population. The fertility of such soils can be improved to enhance crop yield through external use of organic manure such as chicken manure and inorganic fertilizer.

Chicken manure is excellent organic manure, as it contains high nitrogen, phosphorus, potassium and other essential nutrients [4]. It adds organic matter to soil which improves soil structures, nutrient retention, aeration, soil moisture holding capacity and water infiltration [5]. Chicken manure more readily supplies P to plants than other organic manure sources [6]. In Ghana and other tropical countries, research interest recently shifted to utilization of organic wastes as nutrient source in crop production. This is due to high cost and scarcity of mineral fertilizers. Inorganic fertilizer provides readily available nutrients for plant; their use has not always been successful in the tropics, due to enhancement of soil acidity, easy leaching of nutrients, nutrient imbalanced, low organic matter status, reduced crop yield, and degradation of soil physical properties. Although, organic manures exist in readily available forms; cheap and easy to access,

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they need to be applied in large amounts to meet the nutrient requirements of crops [7]. Where large hectares are involved, this single fact play important role in the cost of organic manure application; as it pushes up transportation cost. It is necessary to integrate chemical fertilizers into the organic sources to reduce the quantity required and enhance nutrient release. Owing to the various short comings associated with the use of both sources of fertilizers, a combination of organic and mineral nutrients has been advocated [7]. In view of this there is the need for subsistence farmers who form the bulk of maize production know the best type of fertilizer or combination to be use at different rate to increase food to feed the increasing human populations in an economical way. The study therefore seeks to determine the growth and yield response of two maize varieties to integrated nutrient management of NPK and chicken manure.

2. **Materials and Methods**

2.1 Description of Study Area

Two field experiments were conducted at the Multipurpose crop nursery of the University of Education, Winneba, Mampong- Ashanti campus for two consecutive years (2015 and 2016) during the rainy seasons from May to August. The soil type is the savannah ochrosol formed from the Voltaian sandstone of the Afram plains. Texturally, the soil is friable with a thin layer of organic matter and is deep and brown-sandy loam and well-drained. It however has a good water holding capacity. The soil has been classified by FAO / UNESCO legend as Chronic Luvisol and locally as the Bediesi series with a pH range of 4.0-6.5.

The weather conditions during the two experimental periods show that differences in climatic factors (rainfall, temperature and relative humidity) were observed between both cropping seasons (Table 1). The total monthly rainfall during the 2015 cropping season was 583.1 mm and it occurred from May to August, 2015 with the peak in June and July. The mean monthly

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temperature of the area for the 2015 cropping season ranged between 22.0 °C to 33.7 °C with the highest daily of 33.7 °C occurring in May, 2015. The mean monthly relative humidity for the same experimental period ranged from 58 to 92 % with the peak occurring between June and August. In the 2016 cropping season, for experiment 2, the total monthly rainfall was 437.3 mm and it occurred from May to August, 2016 with the peak between May and July. The mean monthly temperature of the area for the 2016 cropping season ranged between 20.7°C to 31.6 °C with the highest daily of 31.6°C occurring in May, 2016. The mean monthly relative humidity for the experimental period ranged from 62 to 96 % with the peak occurring between June and August (Table 1).

Table 1: Climate data for 2015 and 2016 Experimental periods

Month	Total monthly Rainfall (mm)		Mean monthly Relative humidity (%) (hours GMT)				Mean monthly temperature (^{O}C)			
			06.00	06.00	15.00	15.00	Minimum		Maximum	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
May	118.4	118.6	92	93	58	62	23.4	22.2	32.7	31.6
June	333.4	155.5	92	96	66	68	22.3	21.3	30.2	29.5
July	128.4	108.1	92	96	64	71	22.2	20.9	29.6	27.9
August	2.9	55.1	92	96	66	72	22.0	20.7	28.6	27.6
Total	583.1	437.3								

(Meteorological Department – Mampong Ashanti, 2015, 2016)

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2.2 Soil and Manure Analyses

The chicken manure used for the study for both cropping seasons was from broiler chicken in deep litter system and four months old (20.0% moisture content) was obtained from the poultry farm of the College of Agriculture Education, University of Education, Winneba, Mampong-Ashanti campus and heaped under shade for 30 days to cure well before use. Sub-samples of the dried manure were taken for nutrient analysis. The decomposed and dried chicken manure was spot-applied 6 days before planting maize, and inorganic mineral fertilizer, NPK (15:15:15), applied as basal fertilizer 10 days after planting of seeds at appropriate rates as per treatments [8]. Soil samples were taken prior to chicken manure and inorganic fertilizer application from the top 0-20 cm of plots for chemical analyses. Soil samples and manure analyses were carried out at the Soil Research Institute of CSIR laboratory, Kumasi. The characteristics analyzed for included pH in 1:1 soil: water ratio 1:2 soil: 0.01 $CaCl_2$, Organic matter was determined by the Walkey and Black method and total nitrogen was determined by the micro Kjeldahl method. The available phosphorus was extracted by the Bray's method and exchangeable cations were determined by flame emission photometry.

2.3 Experimental Design and Planting

The experimental design used was a 2 x 5 factorial arranged in randomized complete block design (RCBD) with four replicates made up of two maize varieties and four organic manure and inorganic fertilizer rates was assigned to each block. The two maize varieties (Omankwa and Obatanpa) obtained from CSIR- Crop research institute in Fumesua near Kumasi, Ghana were grown under four fertilizer treatments [(i) 3 t ha $^{-1}$ chicken manure (CM), (ii) Recommended inorganic fertilizer (NPK) (65:38:38 kg ha^{-1} NPK) (iii) ½ CM + ½ NPK (1.5 t ha^{-1} CM + 33:19:19 kg ha^{-1} NPK); (iv) ¾ CM + ¼ NPK (2.25 t ha^{-1} CM + 16: 9.5: 9.5 kg ha^{-1} NPK) and (v)

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No fertilizer (Control)]. Each treatment plot measured 3.2 m x 4.8 m. Three seeds of Omankwa and Obatanpa were planted 0.8 m between rows and at 0.4 m within row plants and later thinned to 2 plants per hill at a depth of 3-5 cm. Each plot had 4 rows of 96 plants. Chicken manure was spot-applied 6 days before planting maize, and inorganic mineral fertilizer, NPK (15:15:15), applied as basal fertilizer 10 days after planting of seeds at appropriate rates as per treatments and sulphate of ammonia was topdressed at 6 weeks after planting [8].

2.4 Data Collection and Analysis

2.4.1 *Vegetative data*

Percentage crop establishment was measured on 40 plants from the two central rows at 4 weeks after planting. Number of leaves per plant was counted on six plants from the two central rows, plant height and stem diameter were measured on six plants from the two central rows with meter rule and vernier caliper respectively, while six plants were randomly sampled for the dry matter accumulation. Data were collected at four weeks after planting and at two weeks interval.

2.4.2 *Yield and yield components*

Number of cobs per plant, total grain yield and yield components including cob diameter, cob length and 100 seed weight were estimated from the two central rows. Data analysis was done using ANOVA and GenStat Statistical Package, version 11.1 [9], Least significant difference (LSD) was used to separate means at 5% level of probability.

Table 2 : Nutrient levels of chicken manure used at the experimental site for the 2015 cropping season

Property	pH	Ca%	Mg%	P%	K%	N%
Chicken manure	6.18	3.40	1.92	0.63	0.86	3.54

Table 3 : Nutrient levels of chicken manure used at the experimental site for the 2016 cropping season

Property	pH	Ca%	Mg%	P%	K%	N%
Chicken manure	5.97	2.11	0.48	0.70	0.01	0.86

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Table 4: Soil chemical properties at the experimental sites for the 2015 and 2016 cropping seasons

	Value	
Property	Untreated soil	
	2015	2016
pH (1:1)	6.13	5.70
Organic carbon (%)	0.64	0.67
Total Nitrogen (%)	0.05	0.06
Organic matter (%)	1.10	1.16
Exchangeable cations (c mol/kg)		
Ca	4.81	4.27
Mg	1.07	0.08
K	0.25	0.07
Na	0.01	0.11
TEB	6.13	5.45
ECEC	6.23	6.00
Base Saturation (%)	98.39	90.83
Available P, mg kg^{-1}	24.32	7.64
Available K, mg kg^{-1}	47.99	11.00

3. **Results**

3.1 Vegetative data

3.1.1 *Percentage crop establishment*

Table 5 shows percentage crop establishment of maize plants as affected by chicken manure and inorganic fertilizer during the 2015 and 2016 cropping seasons. The percentage crop

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establishment during the 2015 and 2016 cropping seasons for the two maize varieties (Omankwa and Obatanpa) ranged from (60.0 - 98.1) and (57.6 - 77.8), respectively (Table 5). There was a significant difference between Obatanpa and Omankwa in percentage crop establishment during the 2015 cropping season (Table 5). Organic and inorganic fertilizer applied singly or in combination did not significantly influence crop establishment across both cropping seasons. Obatanpa and Omankwa grown under ½ CM + ½ NPK produced lower percentage crop establishment in both cropping seasons respectively than same varieties grown on other amended and control plots (Table 5).

Table 5: Percentage crop establishment as influenced by chicken manure and inorganic fertilizer

	Percentage crop establishment (%)			
Fertilizer rates	**2015**		**2016**	
	Omankwa	**Obatanpa**	**Omankwa**	**Obatanpa**
3 t ha^{-1} CM	68.60	98.10	72.90	66.00
65:38:38 kg ha^{-1} NPK	76.90	97.50	77.80	63.20
½ CM + ½ NPK	73.70	91.70	57.60	72.20
¾ CM + ¼ NPK	71.10	98.10	69.40	68.10
Control	60.00	97.50	75.70	61.10
Mean	70.06	96.58	70.70	66.10
LSD (0.05) Var	8.26 *		NS	
LSD (0.05) Fert	NS		NS	
LSD (0.05) Var x Fert	NS		NS	
CV (%)	12.90		16.70	

3.1.2 *Number of leaves per plant*

Obatanpa produced higher number of leaves per plant than Omankwa from 49.63 to77 days after planting (DAP) during the 2015 cropping season (Fig.1). Omankwa and Obatanpa grown under ½ CM + ½ NPK and ¾ CM +1/4 NPK produced the lowest number of leaves per plant from 63 to 77 DAP than the other amended and control plots during the 2015 cropping season (Fig.1).

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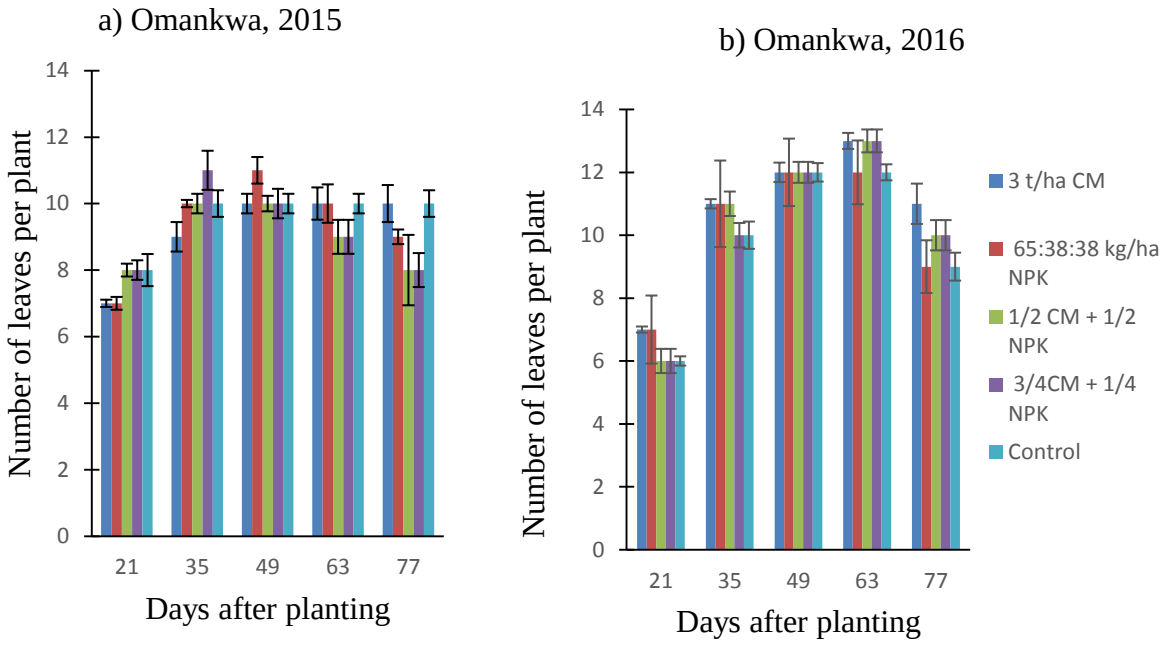
Both maize varieties grown on 3 t ha^{-1} CM produced the highest number of leaves per plant at 77 DAP than the other amended and control plots during the 2016 cropping season (Fig. 1).



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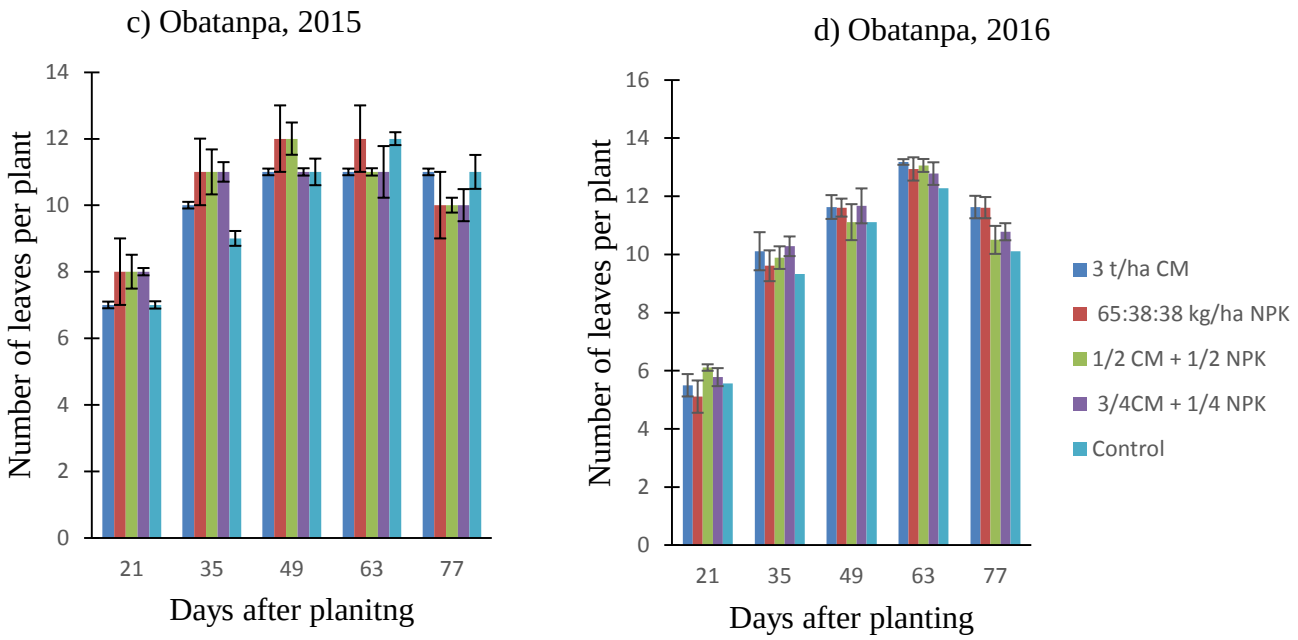

Fig. 1: Effect of chicken manure and inorganic fertilizer on number of leaves per plant of maize from 21 to 77 DAP, 2015 and 2016

3.1.3 *Plant Height*

Obatanpa produced taller plants than Omankwa from 63 to 77 DAP during the 2015 cropping season (Fig.2). Omankwa grown on amended plots produced taller plants than those grown on control plot at 35, 49 and 77 DAP in the same cropping season. The growth rates of Obatanpa grown under amendment and the control during the 2016 cropping season progressively increased with time during the vegetative growth up to 63 DAP with a peak at the same period after which growth declined. Omankwa and Obatanpa grown under 1/2 CM + 1/2 NPK had the tallest plant height at 49 DAP during 2015 and 2016 cropping seasons respectively (Fig 2). Omankwa and Obatanpa grown on control plot produced the shortest plant height from 63 to 77 DAP during 2015 and 2016 cropping seasons respectively (Fig. 2).

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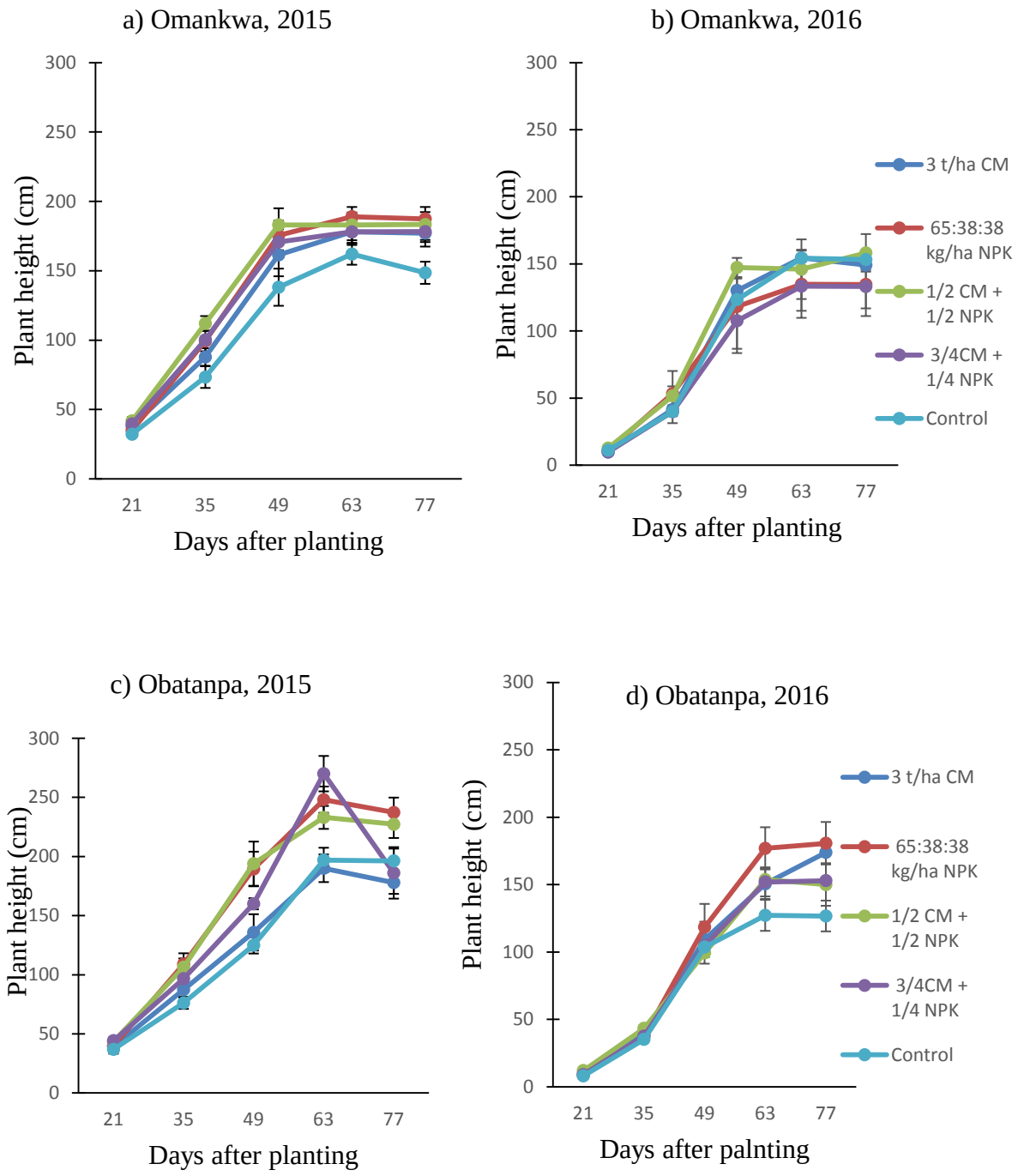

Fig. 2: Effect of chicken manure and inorganic fertilizer on plant height of maize from 21 to 77 DAP, 2015 and 2016

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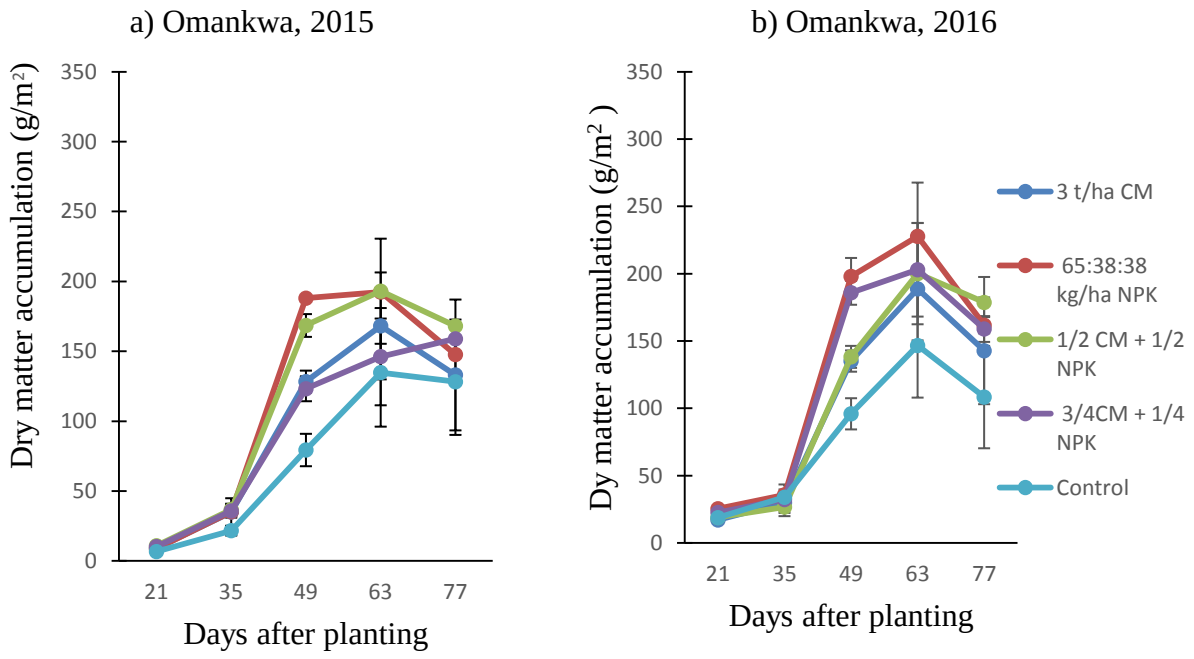
3.1.4 *Dry matter Accumulation*

Omankwa grown on amended plots produced higher dry matter accumulation than the control for the entire 2015 cropping season (Fig. 3). Obatanpa grown under ½ CM + 1/2 NPK produced higher dry matter accumulation from 35 to 49 DAP at the same cropping period. Omankwa and Obatanpa grown on amended plots produced higher dry matter accumulation than the control from 49 to 77 DAP during the 2016 cropping season (Fig. 3). Both maize varieties grown on the control plot produced the lowest dry matter accumulation from 49 to 77 DAP in both cropping seasons. Obatanpa grown under 3 t ha^{-1} CM produced lower dry matter accumulation than the other amended plots from 49 to 77 DAP in both cropping seasons (Fig 3).



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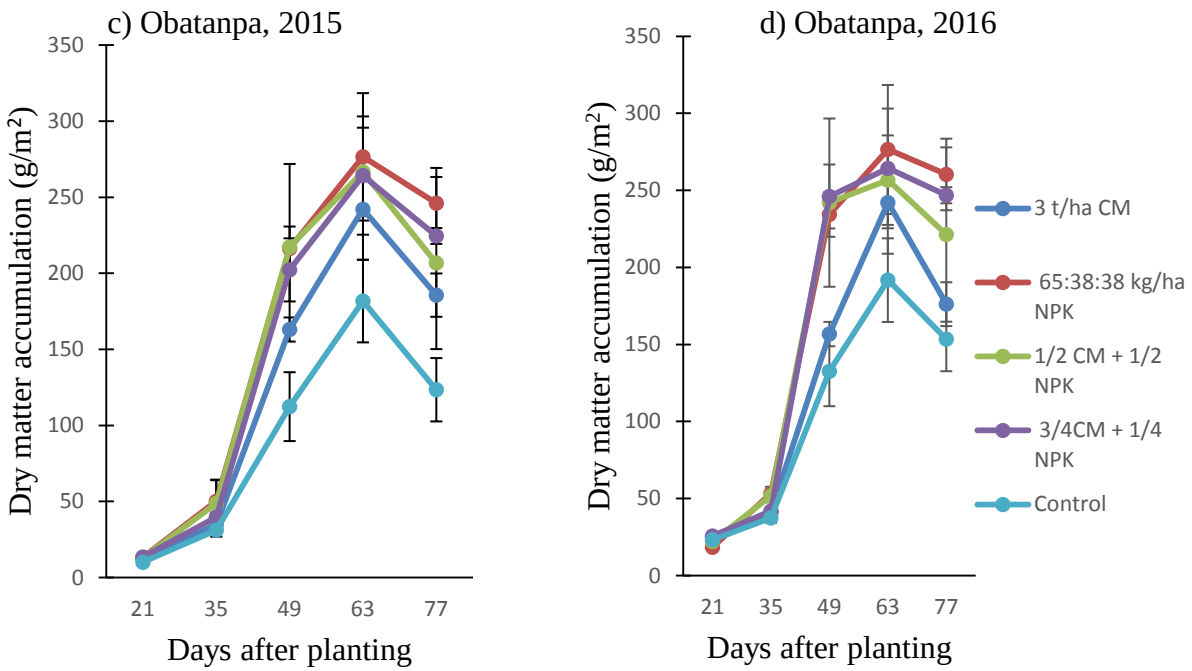

Fig. 3: Effect of chicken manure and inorganic fertilizer on dry matter accumulation of maize from 21 to 77 DAP, 2015 and 2016

3.2 Yield and yield components

3.2.1 *Number of Cobs per plot*

There was a significant difference between Omankwa grown on amended plots except 3 t ha^{-1} CM and the control in number of cobs per plot during the 2015 cropping season (Table 6). Omankwa under ½ CM + ½ NPK differed significantly from 3tha^{-1} CM and the control in number of cobs per plot in the same cropping season. Obatanpa under 65:38:38 k ha^{-1} NPK differed significantly from ¾ CM + ¼ NPK in number of cobs per plot during the 2015 cropping season (Table 6). Omankwa and Obatanpa grown on amended and the control plots did not differ

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significantly in number of cobs per plant during the 2016 cropping season. There was no significant difference between Omankwa and Obatanpa in number of cobs per plot in both cropping seasons (Table 6).

Table 6: Number of cobs per plot as influenced by chicken manure and inorganic fertilizer

	Number of cobs per plot			
Fertilizer rates	**2015**		**2016**	
	Omankwa	**Obatanpa**	**Omankwa**	**Obatanpa**
3 t ha^{-1} CM	17.00	36.00	37.00	33.00
65:38:38 kg ha^{-1} NPK	33.00	43.00	26.00	29.00
½ CM + ½ NPK	34.00	38.00	31.00	34.30
¾ CM + ¼ NPK	29.00	32.00	32.00	36.00
No fertilizer (Control)	15.00	40.00	36.00	34.00
Mean	25.60	37.80	32.50	33.30
LSD (0.05) Var	NS		NS	
LSD (0.05) Fert	6.76 *		NS	
LSD (0.05) Var x Fert	15.11		NS	
CV (%)	27.70		21.40	

3.2.2 *Cob Length*

There was a significant difference between Obatanpa and Omankwa in cob length in both 2015 and 2016 cropping seasons (Table 7). Cob length of Omankwa and Obatanpa was significantly influenced by 65:38:38 kg ha^{-1} NPK from other amended and control plots during the 2015 cropping season. There was no significant difference between amended and the control plots in cob length during the 2016 cropping season. Obatanpa grown on amended and control plots had longer cob length than Omankwa in both cropping seasons (Table 7).

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Table 7: Cob length as influenced by chicken manure and inorganic fertilizer

	Cob length (cm)			
Fertilizer rates	**2015**		**2016**	
	Omankwa	**Obatanpa**	**Omankwa**	**Obatanpa**
3 t ha^{-1} CM	13.45	14.48	23.00	27.60
65:38:38 kg ha^{-1} NPK	15.49	16.06	20.70	26.00
½ CM + ½ NPK	15.09	15.69	21.10	24.50
¾ CM + ¼ NPK	13.84	15.75	22.00	26.90
No fertilizer (Control)	11.14	12.79	22.70	24.50
Mean	13.80	14.95	21.90	25.90
LSD (0.05) Var	1.20 *		1.90 *	
LSD (0.05) Fert	0.76 *		NS	
LSD (0.05) Var x Fert	NS		NS	
CV (%)	6.9		10.20	

3.2.3 *Cob Diameter*

There was a significant difference between Omankwa grown under ¾ CM + ¼ NPK from other amended plots except ½ CM + ½ NPK and the control in cob diameter during the 2015 cropping season (Table 8). Obatanpa grown under 65:38:38 kg ha^{-1} NPK differed significantly from 3 t ha^{-1} CM and the control in cob diameter during the same cropping period. Obatanpa differed significantly from Omankwa in cob diameter during the 2016 cropping season (Table 8). Omankwa and Obatanpa grown under control had the least cob diameter during the 2016 cropping season (Table 8). Obatanpa grown on 3 t ha^{-1} CM, 65:38:38 kg ha^{-1} NPK and ¾ CM + ¼ NPK was similar in cob diameter during the 2016 cropping season. Obatanpa grown on amended and control plots produced thicker cob diameter than Omankwa in both cropping seasons (Table 8).

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Table 8: Cob diameter as influenced by chicken manure and inorganic fertilizer

	Cob Diameter (cm)			
Fertilizer rates	**2015**		**2016**	
	Omankwa	**Obatanpa**	**Omankwa**	**Obatanpa**
3 t ha^{-1} CM	4.48	4.90	5.10	5.70
65:38:38 kg ha^{-1} NPK	4.65	5.24	4.90	5.70
½ CM + ½ NPK	4.77	5.21	5.20	5.40
¾ CM + ¼ NPK	4.84	5.10	5.00	5.70
No fertilizer (Control)	4.53	5.04	4.60	5.20
Mean	4.65	5.10	4.90	5.50
LSD (0.05) Var	NS		0.20 *	
LSD (0.05) Fert	0.18 *		NS	
LSD (0.05) Var x Fert	NS		NS	
CV (%)	4.80		6.10	

3.2.4 *100 Seed Weight*

Omankwa grown on amended plots except ¾ CM + ¼ NPK differed significantly from the control in 100 seed weight during the 2015 cropping season (Table 9). There was no significant difference between Omankwa and Obatanpa in 100 seed weight in both cropping seasons (Table 9). Obatanpa grown on amended plots produced higher 100 seed weight than Omankwa grown on the same treatment in both cropping seasons. Omankwa and Obatanpa grown on control plot produced the least 100 seed weight in both cropping seasons (Table 9).

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Table 9: 100 seed weight as influenced by chicken manure and inorganic fertilizer

	100 seed weight (g)			
Fertilizer rates	**2015**		**2016**	
	Omankwa	**Obatanpa**	**Omankwa**	**Obatanpa**
3 t ha^{-1} CM	30.77	35.13	40.70	50.00
65:38:38 kg ha^{-1} NPK	31.07	35.07	42.70	46.00
½ CM + ½ NPK	30.77	37.13	45.00	47.00
¾ CM + ¼ NPK	30.27	35.03	46.00	46.30
No fertilizer (Control)	27.03	32.87	38.00	37.30
Mean	29.98	35.05	42.50	45.30
LSD (0.05) Var	NS		NS	
LSD (0.05) Fert	3.57*		NS	
LSD (0.05) Var x Fert	NS		NS	
CV (%)	14.40		13.90	

3.2.5 *Total Yield*

There was a significant difference between Obatanpa and Omankwa in total grain yield in both cropping seasons (Table 10). Omankwa and Obatanpa grown on 65:38:38 kg ha^{-1} NPK produced significantly higher total grain yield than the control in both cropping seasons. Obatanpa grown on amended and control plots produced higher grain yield than Omankwa grown on the same plots in both cropping seasons (Table 10). Obatanpa grown on 65:38:38 kg ha^{-1} NPK had higher grain yield of 5668 kg ha^{-1} during the 2015 cropping season and 6938 kg ha^{-1} during the 2016 cropping season (Table 10). Omankwa grown under the same plot had grain yield of 3386 kg ha^{-1} during the 2015 cropping season and 5159 kg ha^{-1} during the 2016 cropping season (Table 10). The yield of Omankwa and Obatanpa grown under organic manure applied alone (3 t ha^{-1} CM) increased by 100% over the control during the 2016 cropping season (Table 10).

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Table 10: Total yield as influenced by chicken manure and inorganic fertilizer

	Total Yield (kg ha^{-1})			
Fertilizer rates	**2015**		**2016**	
	Omankwa	**Obatanpa**	**Omankwa**	**Obatanpa**
3 t ha^{-1} CM	1243.00	2790.00	4993.00	6298.00
65:38:38 kg ha^{-1} NPK	3386.00	5668.00	5159.00	6938.00
½ CM + ½ NPK	3204.00	4259.00	4677.00	6380.00
¾ CM + ¼ NPK	2795.00	3410.00	4988.00	5056.00
No fertilizer (Control)	1088.00	3266.00	2129.00	3163.00
Mean	2343.20	3878.60	4389.20	5567.00
LSD (0.05) Var	840.40 *		461.5 *	
LSD (0.05) Fert	1328.70 *		729.70 *	
LSD (0.05) Var x Fert	NS		NS	
CV (%)	35.20		21.10	

5. Discussion

Maize growth and yield were affected by chicken manure and inorganic fertilizer. The higher number of maize plants established in both 2015 and 2016 cropping seasons might be due to the healthy seeds used as planting materials. However, the varietal difference showed the significant difference in percentage crop establishment during the 2015 cropping season. The lower percentage crop establishment in Obatanpa and Omankwa grown under ½ CM + ½ NPK than same varieties grown on other amended and control plots in both cropping seasons might be that organic manure applied at the same rate and time as inorganic fertilizer was not available to the plants and therefore not yet effective . This contradicts with the findings of [10] that nutrient from mineral fertilizers enhance the establishment of crop when both organic and inorganic fertilizers were combined. The higher number of leaves per plant of Obatanpa from 49, 63 to77 days after planting during the 2015 cropping season probably might be due to outstanding quality with respect to high vegetative growth. The lowest number of leaves per plant of Omankwa and

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Obatanpa grown under ½ CM + ½ NPK and ¾ CM +1/4 NPK from 63 to 77 DAP during the 2015 cropping season is an indication of slow release of nutrients from chicken manure. This findings contradicts those found by [11] that increasing the nitrogen rates resulted in more number of leaves produced per maize plant. The highest number of leaves per plant in both maize varieties grown on 3 t ha^{-1} CM at 77 DAP during the 2016 cropping might be attributed to the solubility, absorption and translocation of the absorbable nutrients by the plant for leaf synthesis as a result of chicken manure which decomposed. This agrees with [12] that application of 30 t ha^{-1} poultry manure to maize gave highest values of the growth in terms of number of leaves per plant. The significant increase in height of Obatanpa than Omankwa in plant height from 63 to 77 DAP during the 2015 cropping season might be due to differences in inherent characteristics of the variety. Omankwa growth in height that was favoured by amendments than the control at 35, 49 and 77 DAP during the 2015 cropping season is an indication that adequate nutrients, required to support early growth can be attained from organic fertilization, by enrichment with inorganic nutrients. This agrees with [13] that 40 -60 % of the organic N in poultry manure are normally mineralized within 90 days. The tallest plant height in Omankwa grown under ½ CM + ½ NPK at 49 DAP in both cropping seasons could be because of the combined effects of the chicken manure improving the physical soil conditions and NPK (15-15-15) also improving the nutrient status of the soil. This is in agreement with the findings of [14] who recorded higher plant heights of maize with the combined application of organic and inorganic fertilizer. The progressive increase in plant height of Obatanpa grown under amendment and the control during the 2016 cropping season with time up to 63 DAP and with a peak at the same period after which growth declined is an indication that the vegetative growth trend follows the normal growth curve of the maize plant. This could be attributed to the

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remobilization of restored carbohydrates in filling the cob or ear. The shorter plant height in control plants at 77 DAP than amended plots during 2015 and 2016 cropping seasons shows that inorganic fertilizer provides plant with immediate plant nutrition while slow mineralization of poultry manure supplies plant subsequent plant nutrient. The significantly higher dry matter accumulation of Obatanpa at 21 DAP and from 49 to 77 DAP than Omankwa during the 2015 cropping season was favoured by tall plants produced. This agrees with [15] that more plant height due to better usage of sunlight in competing with weeds have positive effect on total dry matter. Omankwa growth in dry matter accumulation that was favoured by application of 65: 38:38 kg ha^{-1} NPK at 49 DAP during both cropping seasons is an indication of mineralization and fast release of N.P. and K which promoted vigorous foliage growth and favoured the synthesis of more photo-assimilates. The lowest dry matter accumulation of both maize varieties grown on control plot from 49 to 77 DAP in both cropping seasons shows that the presence of nutrients in the soil help in dry matter accumulation. The lower dry matter accumulation of Obatanpa grown on 3 t ha^{-1} CM than the other amended plots from 49 to 77 DAP in both cropping seasons might be due to slow release of nutrient by chicken manure.

The significant increase in number of cobs per plot with Omankwa grown under ½ CM + ½ NPK than the other amended and control plots during the 2015 cropping season is an indication that adequate nutrients from organic and inorganic fertilization is required to support early cob growth. This agrees with the findings of [16] that combination of organic and inorganic fertilizer results into synergy and improved conservation and synchronization of nutrient release and crop demand, leading to increased fertilizer efficiency and higher number of grain/cob. The greater number of cobs per plot with Obatanpa grown under 65:38:38 kg ha^{-1} NPK as compared to ¾ CM + ¼ NPK during the 2015 cropping season is attributed to fast release of mineral nutrient

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from the inorganic fertilizer. Higher rates of inorganic fertilizer application produced better response with respect to higher number of cob possibly because higher rates satisfied the crop's requirement [16]. The longest cob length of Omankwa and Obatanpa grown under 65:38:38 kg ha^{-1} NPK during the 2015 cropping season might be due to fast release of N, P and K. The inorganic fertilizer provides source of necessary macro nutrients in available forms, thereby improving the biological properties of the soil [17] which might have accounted for the longer cob length obtained in inorganic fertilizer treated plots as against organic manure and the control. The longer cob length of Obatanpa than Omankwa in both cropping seasons might be due to differences in variety and its response to climatic conditions experienced during the cropping periods.

The significant thicker cob diameter with Omankwa and Obatanpa grown under ¾ CM + ¼ NPK and 65:38:38 kg ha^{-1} NPK over the control might be due to the application of high rate of chicken manure and NPK to both maize varieties which have resulted in high inherent nutrients in the manures which promoted broader grain size and heightened meristematic activities that favoured the enlargement of cob. The thicker cob diameter with Obatanpa than Omankwa during the 2016 cropping season is attributed to differences in variety. The lowest cob diameter with Omankwa and Obatanpa grown under control during the 2016 cropping season confirm the deficiency of OM, N and P in the soil and poultry manure as effective source of plant nutrients. Addition of poultry manure and mineral fertilizer made more nutrients available to maize plants.

The significant increase in 100 seed weight of Omankwa grown on amended plots except ¾ CM + ¼ NPK over the control during the 2015 cropping season could be due to higher rate of nitrogen in chicken manure and inorganic fertilizer that resulted in higher nutrient release for heavier seed weight than the control. The heavier 100 seed weight of Obatanpa grown on

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amended plots than Omankwa grown on the same treatment in both cropping seasons might be due to differences in variety and its response to soil mineral nutrient. Maize grain yield was significantly increased with fertilization. The significant increase in grain yield of both maize varieties grown on 65:38:38 kg ha^{-1} NPK in both cropping seasons is an indication of early release of mineral nutrient from inorganic fertilizer which was made readily available to plants for their growth and development. Inorganic fertilizer provides source of macro nutrients in available forms which must have accounted for the better yield performance obtained in inorganic fertilizer treated plot as against the other amended and control plots. An increase in crop yield with inorganic fertilizer application to maize was reported by [18]. Similar result was reported by [19] that inorganic fertilizer improved yield over 50% than their unfertilized counterparts. The superiority of plants that received inorganic fertilizer over other plants with respect to higher grain yield could also be attributed to better yield enhancement credited to inorganic fertilizers over other nutrient sources. It is also consistent with the findings of [20] on Cayene pepper. Abundant evidences that inorganic fertilizers can improve yield of maize crop significantly has been reported by [21]. The greater grain yield of Obatanpa grown on amended and control plots than Omankwa grown on the same plots in both cropping seasons is attributed to inherent characteristics of the variety and its response to soil nutrient and climatic conditions experienced during the cropping periods. This is consistent with the findings of [22] and [23] who reported that grain yield is usually influenced by genetic quality of individual variety.

6. Conclusion

Obatanpa which was outstanding in maize grain yield, cob diameter and length should be grown by farmers. Farmers who prefer mineral fertilizers for increased grain yield and thicker cob diameter of maize should apply 65:38:38 kg ha^{-1} NPK, although continuous application of

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chemical fertilizer may not sustain the growing field for future generation as well as human health. Farmers who practice organic agriculture in transitional agro-ecological zone of Ghana should apply 3 t ha^{-1} CM and ¾ CM + ¼ NPK to enhance maize grain weight, cob length and cob diameter respectively. Substitution of some portion of chemical fertilizers along with organic manure will maintain and sustain soil health as well as improve economic stability of farmers.

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